DISSECTION OF A HUMPBACK WHALE CALF LARYNX WITH PARTICULAR REFERENCE TO THE RELATIONSHIPS OF THE VENTRAL DIVERTICULUM

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The larynx of a humpback whale calf was sectioned transversely and orientated with a specimen of similar size which had been sectioned longitudinally (Quayle, 1991). The relationships of the ventral diverticulum (or sac) and its histological appearances are described as well as possible function of this structure which is unique to baleen whales. ❐ *Humpback whale, Megaptera novaeangliae, larynx, ventral diverticulum, relationships and possible function.*

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The ventral laryngeal diverticulum (or sac), unique to baleen whales, was first described in a piked whale (= minke whale, *Balaenoptera acutorostrata*) by Hunter (1787) who presumed that whales did not produce sound as they lacked vocal cords. Payne & McVay (1971) established that humpback whales (*Megaptera novaeangliae*) produce elaborate sounds in the form of song but the means of production remain speculative. Hosokawa (1950) reviewed the literature, concerning the anatomy and possible function of the diverticulum, published in the two centuries following Hunter's observations and contributed substantially to that knowledge principally by detailed dissection of an adult sei whale (*Balaenoptera borealis*) larynx.

Opportunities to dissect baleen whale larynges in Queensland have been limited to neonatal and sub-adult specimens (Quayle, 1991; Paterson, 1994; Paterson et al., 1993) with the exception of one adult *B. acutorostrata* (Paterson et al., 2000). A further humpback whale calf laryngeal dissection is described in this paper.

MATERIAL AND METHODS

A 3.6m long female humpback whale calf, with umbilical cord attached, was found dead at Dundubara (25°10'S, 153°17'E) on the eastern shore of Fraser Island on 26 July 1999. The larynx was removed in a fresh state, frozen immediately, transported to the Queensland Museum and registered QMJM13647.

The larynx was subsequently thawed and sectioned serially in the transverse plane. Five of those sections are described, commencing with the most caudal, with reference to a longitudinal section (Fig. 1) of a male humpback whale calf larynx (Quayle, 1991).

The tracheal lumen, fundus of the ventral diverticulum and the oesophageal lumen are shown in section I (Fig. 2). Minimal invagination of the tracheal lumen by the diverticulum is evident. In section II (Fig. 2) the diverticulum 'extends' into the lumen via the ventral deficiency in the tracheal cartilages. The oesophagus is dorsal to the trachea. In section III (Fig. 2), made at the caudal margin of the interarytenoid bar (or fibro-elastic connection), the thick walled diverticulum reduces the tracheal lumen to a crescentic slit. The diverticular lumen is small. The oesophagus, with thick musculature at that level, is again seen dorsally. In section IV (Fig. 2), made at the mid cricoid level, the paired arytenoid bodies are seen. In life, the air stream would pass between their medial surfaces to enter (or exit) the trachea or diverticulum. A groove between the ventral aspects of the arytenoids leads into the neck of the diverticulum which is narrowest ventral to the interarytenoid bar. Section V (Fig. 2), the most cephalad section, was obliquely cut with resultant 'displacement' of the cricoid to the right of the figure. The paired arytenoids are again demonstrated. The wide ventral passage leads to the neck of the diverticulum.

Histological examination of the diverticulum demonstrated that its mucosal surface comprised non-ciliated, pseudo-stratified epithelial cells with abundant mucous secreting glands in the submucosa (Fig. 3A,B). The underlying muscle was striated and typical of voluntary (skeletal) muscle (Fig. 3C). Other sections, although not illustrated here, demonstrated that the muscular bands were often disposed both circumferentially and longitudinally.

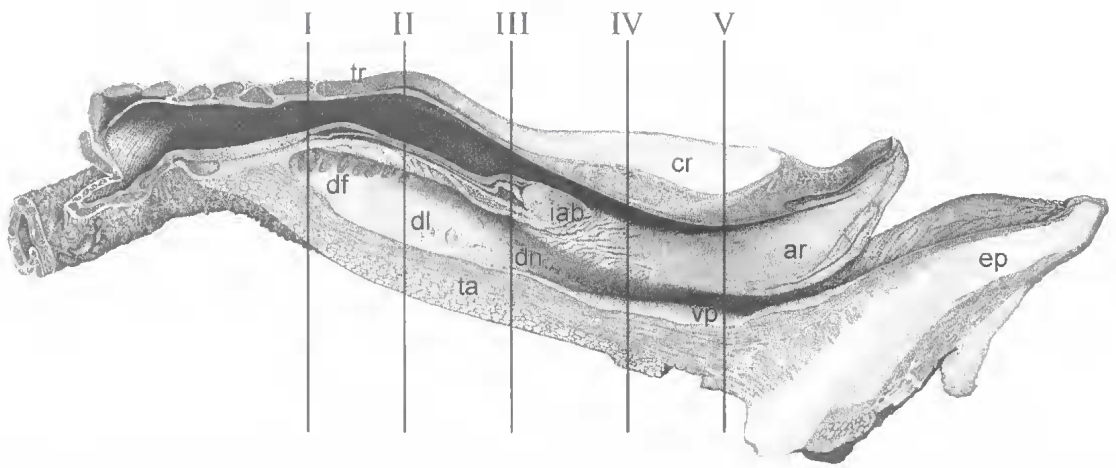

FIG. 1. Positions from which transverse sections of QMJM13647 were cut. They are orientated with a longitudinal section in medial aspect of a humpback whale calf larynx, Quayle (1991). The tracheal lumen in that specimen widened following formalin fixation. ar = arytenoid cartilage; cr = cricoid cartilage; df = fundus of diverticulum; dl = lumen of diverticulum; dn = neck of diverticulum; ep = epiglottic cartilage; iab = inter-arytenoid bar; ta = thyro-arytenoid muscle; tr = trachea; vp = ventral air passage.

The diverticulum was 10cm long with a relatively small lumen and an extremely thick muscular wall. It was probably non-distensible (at least in this neonate). Its contents (air and/or water) could be expelled into the larynx proper between the bodies of the arytenoids. However, if they were apposed, thus closing the entrance to the diverticulum (Paterson, 1994, fig. 1 demonstrated the narrow diverticular entrance in *B. acutorostrata*), the diverticulum may 'round-up' on contraction and reduce the tracheal lumen from its ventral aspect. Simultaneous contraction of surrounding muscles (thyro-arytenoid in particular) could assist in maintaining the diverticulum in that position.

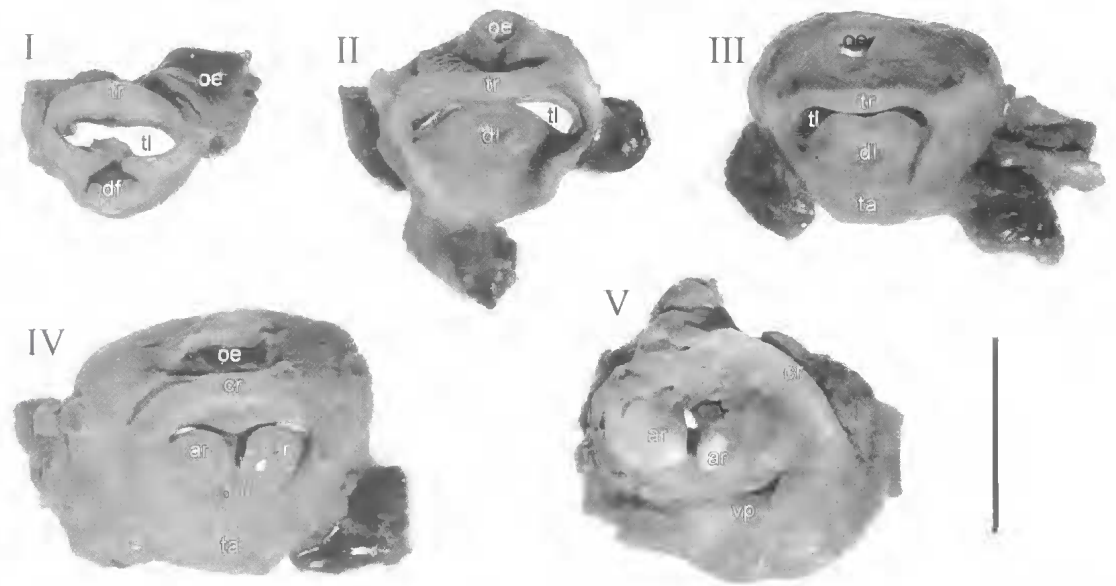

FIG. 2. Transverse laryngeal sections I-V of QMJM13647. ar = arytenoid cartilages; cr = cricoid cartilage; df = fundus of diverticulum; dl = lumen of diverticulum; dn = neck of diverticulum; oe = oesophagus; ta = thyro-arytenoid muscle; tl = tracheal lumen; tr = trachea; vp = ventral air passage. Scale bar = 10cm.

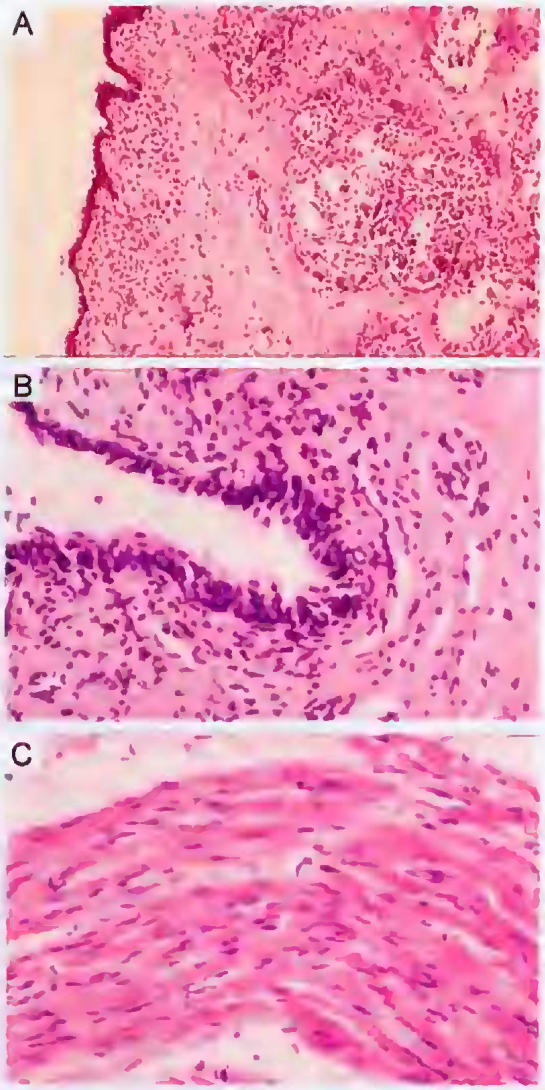

FIG. 3. Histological sections, stained with haemotoxylin and eosin, of the ventral diverticulum of QMJM13647. A, low-power view of mucosa and submucosa demonstrating mucous secreting glands; B, high-power view of mucosa demonstrating non-ciliated, pseudo-stratified epithelium; C, high-power view of stratified muscle typical of voluntary (skeletal) muscle.

DISCUSSION

Hosokawa (1950) suggested three possible functions for the diverticulum viz. a valve to prevent water and/or food entering the respiratory tract; a reservoir of air to assist respiration while the whale was submerged; a phonation apparatus. He also noted that its function (if any) may be unrelated to those possibilities. Haldiman & Tarpley (1993) described in detail, by reference to transverse sections, the larynx of an 8.5m long bowhead whale (*Balaena mysticetus*). They considered the diverticulum to be an integral part of the ventral tracheal wall and that its enlargement should act to occlude the tracheal lumen. They also suggested that movement of air, in and out of the diverticulum, could in theory produce sound by 'fluttering' action but noted that the function of the diverticulum is not provable at present. Turner (1872) considered that phonation was possible during expiration by vibration of the elongated caudal processes of the arytenoids and this would not require 'assistance' from the diverticulum. Quayle (1991) suggested that phonation could occur between the opposing arytenoids. Humans who have a supra-cricoid laryngectomy for cancer, in which operation the vocal cords are removed but the arytenoids retained, can produce a satisfactory voice using the arytenoids as the vibratory segment (W.B. Coman, pers. comm.).

I have not examined an adult humpback whale larynx, but Hosokawa (1950) noted that the diverticulum of a humpback whale foetus was small relative to other baleen whales. Baleen whales gulp large volumes of water when feeding and generate high oral and presumably pharyngeal pressures during filtration and deglutition. Consequently, tracheal occlusion may assist in protecting the tracheo-bronchial structures from misplaced water in addition to the usual epiglottic valvular function. There is consensus that the diverticulum of baleen whales is capable of tracheal occlusion. Dissection of an adult humpback whale larynx, particularly a male (the 'singing' sex) in the breeding season when most phonation is believed to occur (Cato, 1991), is awaited to provide a further step in this question which has featured prominently in cetacean scientific literature for two centuries.

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